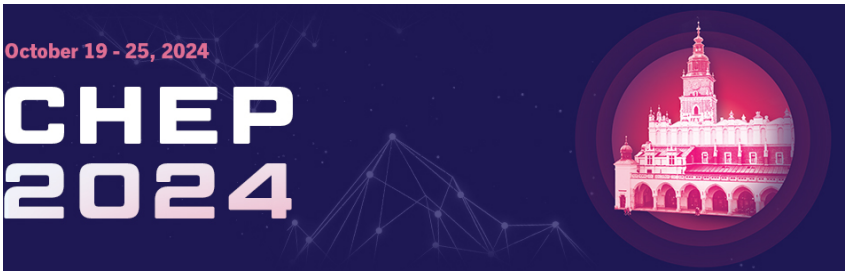

Contribution ID: **525** Contribution code: **THU 24** Type: **Talk**

Numerical studies of space charge effect on particle tracking in a small TPC

Tuesday 22 October 2024 16:51 (18 minutes)

In the realm of low-energy nuclear physics experiments, the Active Target Time Projection Chamber (AT-TPC) can be advantageous for studying nuclear reaction kinematics, such as the alpha cluster decay of ^{12}C, by tracking the reaction products produced in the active gas medium of the TPC. The tracking capability of the TPC is strongly influenced by the homogeneity of the electric field applied across its drift medium, which is affected by the space charge produced by low-energy projectiles and reaction products in the active gas medium through the ionization process. In this work, we implemented a mathematical model based on a hydrodynamic approach to simulate the space charge effect caused by the alpha beam on the TPC performance using the platform of a commercial Finite Element Method (FEM) package available in COMSOL Multiphysics. This novel approach is computationally less expensive compared to the particle model. The primary ionization caused by the alpha particles was simulated using Geant4, and the electron transport parameters for the active gas were obtained from MAGBOLTZ. The effect of space charge on the applied electric field and the angular resolution of the TPC with beam currents ranging from a few pA to 20 pA have been reported. The same model was also utilized to simulate the temporal evolution of an alpha track in two different active gas mediums, $He + CO_2$ and He+C_4H_{10}, in the volumetric ratios of 90:10 and 93:7, respectively. Different readout geometries of the TPC were studied to find the optimum strip width and number of strips at the TPC end cap to properly resolve the alpha particle tracks. A tracking algorithm had been developed to distinguish between the multiple tracks between scattered events and the ^{12}C breakup. We are designing a 64 channel Micromegas based prototype TPC on the basis of the simulation results.

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Session Classification: Parallel (Track 5)

Track Classification: Track 5 - Simulation and analysis tools